MULTIMEDIA UNIVERSITY ™

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2022/2023

ETM2156 - FUNDAMENTALS OF COMMUNICATIONS

(TE)

10 JULY 2023

9.00 a.m – 11.00 a.m.

(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 6 pages including cover page and appendixes with **FOUR** Questions only.
2. Attempt **ALL** questions. The distribution of the marks for each question is given.
3. A **table of Bessel functions** and a **table of trigonometric identities** are enclosed.
4. Please write all your answers in the Answer Booklet provided. All necessary working **MUST** be shown.
5. It is your responsibility to make sure that all your answer script is submitted at the end of the examination time.

Question 1 [25 marks]

(a) Define the modulation index of an amplitude modulation (AM) transmission. Briefly describe the situation when the modulation index is larger than unity. [6 marks]

(b) ***Figure Q1*** shows an analog audio $s_m(t)$, modulates a carrier of frequency 250 kHz and amplitude of 1V, using a Double-Sideband Suppressed-Carrier (*DSB-SC*) modulator, and produces an output $s_{\tilde{m}}(t)$ as follows,

$$s_{\tilde{m}}(t) = 12.5[cos(0.498x10^6\pi t) - cos(0.502x10^6\pi t)]$$

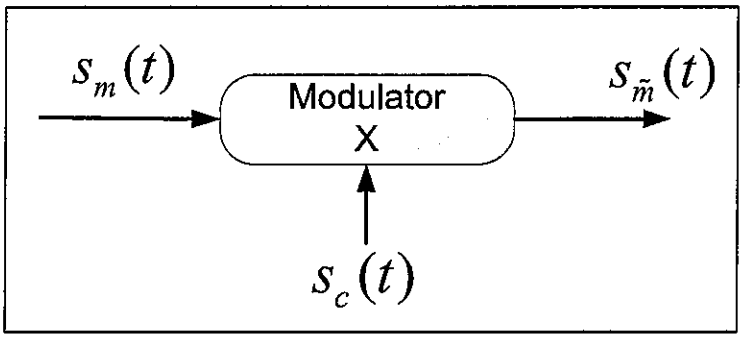

Figure Q1

(i) Determine the time-domain expression for the audio signal. Sketch both audio and carrier signals. [11 marks]

(ii) Sketch the amplitude spectrum of the modulated signal, $s_{\tilde{m}}(t)$ showing all the spectral amplitudes. [3 marks]

(iii) Again, sketch the respective amplitude spectrum if a high-pass filter with cut-off frequency of 250 kHz is applied to the output of *Modulator X*. Base on your sketching, name the modulation scheme used and highlights TWO advantages of the scheme. [5 marks]

Continued ...

Question 2 [25 marks]

(a) Explain the reason on why the message signal using a frequency modulation (FM) transmission is less susceptible to noise interference in comparison with an amplitude modulation (AM) transmission. [5 marks]

(b) Given an expression for the instantaneous frequency of a modulated FM signal as

$$f_i(t) = (4 \times 10^6) - 100\sin(1000\pi t)$$

Assuming that the amplitude of modulating signal, $A_m = 0.2V$ and the carrier amplitude, $A_c = 1V$;

(i) Find out maximum frequency deviation, Δf, the modulating signal frequency, f_m, frequency sensitivity, k_f and modulation index, β. [5 marks]

(ii) Using Bessel function table, sketch the frequency spectrum and find the approximate bandwidth. [6 marks]

(iii) Derive the expression of the FM modulated waveform. [5 marks]

(iv) Calculate the bandwidth using Carson's Rules. Compare the answer to the bandwidth obtained in Question 2(b)(ii) and describe your observation. [4 marks]

Question 3 [25 marks]

(a) An input signal as illustrated in *Figure Q3a* is applied a Pulse Code Modulation (PCM) technique with uniform quantization to produce a binary output. Given the average power of input signal is 30mW and target output signal-to-noise ratio (SNR) is 20dB, determine the following:

(i) Calculate the number of bits required to represent each sample. [7 marks]

(ii) Identify the transmission bandwidth [4 marks]

(iii) The average output signal-to-noise ratio, $(SNR)_O$ in decibel. [2 marks]

(iv) The bit rate. [4 marks]

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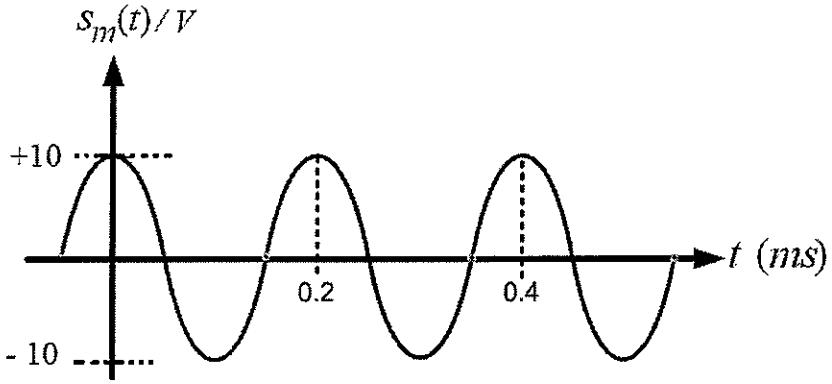

Figure Q3a

(b) Consider a Pulse Code Modulation (PCM) bit stream in *Figure Q3b*. Sketch the resulting transmitted coded signal for the following line coding techniques:

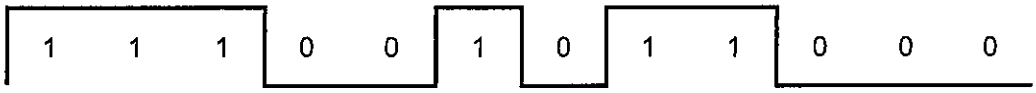

Figure Q3b

Sketch the resulting transmitted coded signal for the following line coding techniques:

(i) Unipolar NRZ (nonreturn-to-zero). [2 marks]

(ii) Polar NRZ (nonreturn-to-zero). [2 marks]

(iii) Bipolar RZ (return-to-zero) [2 marks]

(iv) Manchester NRZ (nonreturn-to-zero) [2 marks]

Continued ...

Question 4 [25 marks]

(a) An eye pattern is a tool that developed to evaluate the performance of a transmission system. With the aid of diagram, describe TWO (2) important information that might be evaluated from an eye pattern. [6 marks]

(b) A four-level pulse sequence, which has a data rate R_b = 2,400 bits/s, is transmitted over a baseband system. If the system transfer characteristic is a raised cosine spectrum with a 100% roll-off, compute the required transmission bandwidth. [6 marks]

(c) A 4,800 bits/s data terminal is connected to a modem. Calculate the transmission bandwidth B_T required at the modem output for each of the following schemes. (50% roll-off shaping is used in all cases)

(i) Baseband bandwidth [3 marks]

(ii) Binary ASK transmission. [2 marks]

(iii) Binary FSK transmission with frequency deviation of ±3,600 Hz about the carrier. Also, find the modulation index. [5 marks]

(iv) 16-level QAM. [3 marks]

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Appendix A: Table of Bessel Functions

n \ β	0.05	0.1	0.2	0.3	0.5	0.7	1.0	2.0	3.0	5.0	7.0	8.0	10.0
0	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0178	0.300	0.172	-0.246
1	0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328	-0.005	0.235	0.043
2		0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	-0.301	-0.113	0.255
3				0.001	0.003	0.007	0.020	0.129	0.309	0.365	-0.168	-0.291	0.058
4						0.001	0.002	0.034	0.132	0.391	0.158	-0.105	-0.220
5								0.007	0.043	0.261	0.348	0.186	-0.234
6								0.001	0.011	0.131	0.339	0.338	-0.014
7									0.003	0.053	0.234	0.321	0.217
8										0.018	0.128	0.223	0.318
9										0.006	0.059	0.126	0.292
10										0.001	0.024	0.061	0.208
11											0.008	0.026	0.123
12											0.003	0.010	0.063
13											0.001	0.003	0.029
14												0.001	0.012
15													0.005
16													0.002
17													0.001

Appendix B: Table of Trigonometric Identities

$$\sin A \sin B = \frac{1}{2}\left[\cos(A-B) - \cos(A+B)\right]$$

$$\cos A \cos B = \frac{1}{2}\left[\cos(A+B) + \cos(A-B)\right]$$

$$\sin(A+B) = \sin A \cos B + \cos A \sin B$$

$$\cos(A+B) = \cos A \cos B - \sin A \sin B$$

$$\sin\theta = \frac{1}{2j}\left[e^{j\theta} - e^{-j\theta}\right]$$

$$\cos\theta = \frac{1}{2}\left[e^{j\theta} + e^{-j\theta}\right]$$

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